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CATEGORY II PERFORMANCE AND FLYING QUALITIES TESTS OF THE HH-53C HELICOPTER

-SUPPLEMENT-

EVALUATION OF THE HH-53C SINGLE-ENGINE HEIGHT-VELOCITY CHARACTERISTICS

AFFTC

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TECHNICAL REPORT No. 70-8

JULY 1970

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AIR FORCE FLIGHT TEST CENTER
EDWARDS AIR FORCE BASE, CALIFORNIA
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AERONAUTICAL SYSTEMS DIVISION (AFSC)
WRIGHT PATTERSON AIR FORCE BASE OHIO 45433

ATTN OF: ASD/SDQH 5-8 (Maj Thompson/54921/cal/H-53/R&D 9-2)

SUBJECT: ASD Addendum to FTC-TR-70-8 Supplement, H-53 Height Velocity

TO: Recipients of FTC-TR-70-8 Supplement

This report is a part of and should remain attached to FTC-TR-70-8 Supplement, "Evaluation of the H-53 Single-Engine Height-Velocity Characteristics". Paragraph numbers below correspond to the recommendations in the AFFTC Technical Report.

1. Concur with intent. This type information is required for adequate flight manual guidance. ASD substantiated the requirement for H-53 Follow-On Evaluation to accomplish several test objectives, including additional height-velocity data at altitude. Refer to FTC-TR-71-54 and ASD Addendum for results.

2. Concur with intent. ASD has initiated action to incorporate the required information in the aircraft flight manual.

FOR THE COMMANDER

WILLIAM D. EASTMAN, JR., Lt Col, USAF
Chief, Helicopter Program Office
Directorate of Combat Systems
Deputy for Systems

FTC-TR-70-8

Final rpt.

CATEGORY II PERFORMANCE AND FLYING QUALITIES TESTS OF THE HH-53C HELICOPTER.

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AFFTC-69-2

Jul 70

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FOREWORD

This report contains the results of the single-engine height-velocity test of the HH-53C helicopter. This data was not included in FTC-TR-70-8, Category II Performance and Flying Qualities Tests of the HH-53C Helicopter, reference 1. At the time of preparation of that report, the contractor had not yet completed tests required to clear the aircraft for height-velocity testing. The test was conducted under the authority of AFFTC Project Directive 69-2 with an AFFTC priority of 25. The program structure was 482A.

Foreign announcement and dissemination by the Defense Documentation Center are not authorized because of technology restrictions of the U.S. Export Control Acts as implemented by AFR 400-10.

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ABSTRACT

This report presents the results of a flight test program conducted to quantitatively and qualitatively verify the contractor's single-engine height-velocity curve and to determine compliance with MIL-H-8501A, Helicopter Flying and Ground Handling Qualities; General Requirements for. The results of these tests verified the height-velocity characteristics previously established by the contractor. Because of limitations imposed by the tail boom configuration, touchdown speeds consistently exceeded the 15-knot maximum allowed in MIL-H-8501A. Since all HH-53C single-engine height-velocity testing has been conducted at sea level, it was recommended that further testing be done at altitude.

Table of Contents

INTRODUCTION

This report presents the results of a 10-flight evaluation of HH-53C helicopter, USAF S/N 67-14993, which was flown at Sikorsky Aircraft Division of United Aircraft Corporation in Stratford, Connecticut. These flights were conducted from 12 May to 5 June 1970 and required a total flight time of 7.1 hours.

The purpose of the test program was to quantitatively and qualitatively verify the contractor's single-engine height-velocity curve and to determine compliance with paragraph 3.5.7 of MIL-H-8501A, Helicopter Flying and Ground Handling Qualities; General Requirements for, reference 2.

The evaluation was conducted with the 450-gallon external fuel tanks installed. The engines were not equipped with engine air particle separators.

TEST AND EVALUATION

Height-Velocity Characteristics

The minimum altitude and airspeed combinations from which a safe single-engine landing could be made following a failure of one engine were determined at a gross weight of approximately 37,000 pounds and a pressure altitude of sea level.

The tests were conducted with the automatic flight control system on and with a center of gravity location at station 336. The operative engine was trimmed to produce an output of 100 percent torque at 100 percent rotor rpm. Single-engine failures were simulated by retarding the number 1 engine throttle to the ground idle position. No corrective action was taken by the pilot for at least 2 seconds following the simulated engine failure to allow for the expected delay in pilot reaction following an actual engine failure.

Two curves were obtained, one defining the area from which a go-around could be made and the other showing the area in which a hard landing with possible aircraft damage was likely. The envelope between the curves allowed a safe landing, but there was not sufficient speed or altitude to effect a go-around (figure 1). Although examination of figure 1 shows that safe landings or go-arounds were made from below the recommended curves, above average pilot proficiency and practice were required to obtain this performance.

The HH-53C was capable of making a go-around following the failure of one engine under the test conditions if an indicated airspeed of 35 knots could be obtained. From a hover this required 300 feet altitude and the nose of the helicopter had to be lowered to 20 degrees nosedown on the attitude indicator. The collective pitch was lowered slightly to regain the rotor rpm, then used to maintain 98 to 100 percent rotor rpm. When engine failure was initiated at heights of less than 300 feet, more airspeed was required at the time of engine failure and less pushover was required to obtain the necessary airspeed to go-around. With an engine failure speed of 30 KIAS, go-arounds were accomplished from ground level and required the nose to be lowered 2 to 3 degrees. Probably because of ground effect, the operating engine had more than sufficient power to sustain level flight up to 50 feet above the ground, so the collective pitch could be raised slightly to aid aircraft acceleration at very low heights above the ground.

An engine failure within the AVOID area would result in almost certain aircraft damage. To effect a safe landing following an engine failure from the area between the two curves a minimum of 25 to 30 KIAS was obtained by lowering the nose approximately 20 degrees nosedown on the attitude indicator at all altitude/airspeed combinations above 75 feet. The collective pitch was lowered slightly to obtain and maintain 98 to 100 percent rotor rpm. Below 75 feet the necessary nosedown angle progressively decreased as the height above the ground decreased. Below 50 feet, the rotor rpm was allowed to decay because the collective pitch was decreased only a small amount. This prevented the buildup of an excessive rate of descent near the ground.

HH-53C USAF S/N 67-14993
T64-GE-7 ENGINES

Notes:

1. SIMULATED SINGLE-ENGINE FAILURE
2. ROTOR SPEED AT ENGINE FAILURE = 195 RPM (105 PERCENT)
3. GROSS WEIGHT ≈ 37,000 POUNDS
4. cg LOCATION STATION 336
5. LANDING GEAR DOWN
6. PRESSURE ALTITUDE ≈ SEA LEVEL
7. FREE AIR TEMPERATURE = 19 deg C
8. ○ SYMBOLS ARE POINTS WHERE A LANDING WAS REQUIRED
9. □ SYMBOLS ARE POINTS WHERE A GO-AROUND WAS MADE

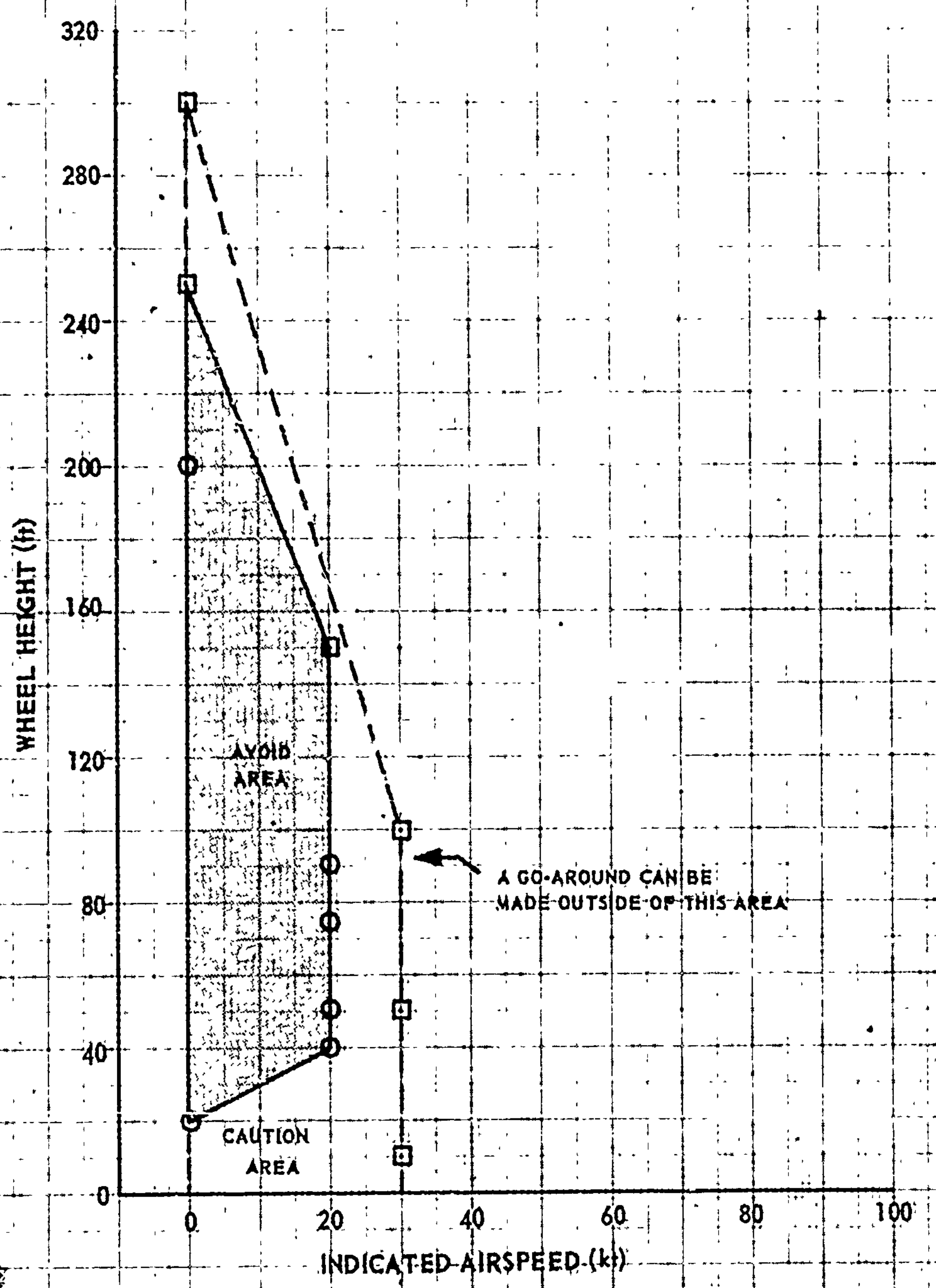

Figure 1 HEIGHT-VELOCITY DIAGRAM

Two flare and landing techniques were evaluated. The first technique, the primary one used during this evaluation, was accomplished by holding the desired speed (25 to 30 KIAS) until about 10 feet above the ground, then rotating to a 10-degree noseup attitude indication on the artificial horizon. The helicopter was held off the ground with the collective pitch as long as possible to produce the lowest possible touchdown speed. The second technique used a moderate flare above 25 feet to decelerate, followed by a pushover to a landing attitude, and cushioning the touchdown with the collective pitch. Both techniques yielded essentially the same touchdown speeds. The first technique required more distance, but provided better control over the touchdown impact. The second method gave a shorter total landing distance (from simulated engine failure to stop), but increased the possibility of a hard landing because the collective pitch application had to be timed quite precisely.

Touchdown speeds using either technique were well above the 15-knot maximum spelled out in MIL-H-8501A. The HH-53C had to be established in a nearly level attitude at touchdown to preclude striking its long, low tail boom on the ground. Therefore, any flare to decelerate the helicopter must be accomplished well above the ground, and if held too long, could result in the aircraft falling through to a hard landing (reference 1).

The results of this evaluation verified the single-engine height-velocity characteristics previously established by the contractor. Since these tests and those of the contractor were performed only at sea level, further tests should be performed to define the single-engine height-velocity characteristics at altitude. (R 1)[1]

The Flight Manual contains no discussion on techniques to be followed for an engine failure near the AVOID area of the height-velocity curve.

The following discussion should be included in section III of the Flight Manual Emergency Procedures under Engine Failure to improve its usefulness (R 2):

> The failure of an engine near the AVOID area of the height-velocity diagram requires prompt corrective action by the pilot if a safe landing or go-around is to be made. Altitude permitting, the helicopter must be rapidly established in at least a 20-degree nosedown attitude to provide proper acceleration to flare or go-around airspeed. The collective pitch must be lowered to obtain and maintain 98 to 100 percent rotor rpm with maximum available torque. As the desired airspeed is approached, the helicopter should be slowly returned to a level attitude.
>
> As the altitude at which an engine failure occurs decreases below 75 feet, a progressively shallower nosedown attitude should be used. Below 50 feet the collective pitch must be lowered very slowly, allowing rotor rpm to decrease to avoid obtaining an excessively high rate of descent. As ground

[1]Numbers indicated as (R 1), etc., represent the corresponding recommendation numbers as tabulated in the Conclusions and Recommendations section of this report.

contact is neared, cushion the touchdown with the collective pitch.

The ability to make a go-around is first dependent upon having the capability of maintaining level flight on one engine. The minimum speed at which level flight can be sustained depends upon the gross weight of the helicopter and the density altitude (i.e., 35 KIAS at 37,000 pounds and 5,000 feet density altitude). The helicopter must be accelerated to above the minimum speed at which level flight can be maintained. Acceleration should be continued in level flight until best single-engine climb speed is attained.

A landing following an engine failure from above 75 feet will require a minimum of 30 KIAS at flare altitude. If sufficient prepared surface is available, a normal single-engine running landing can be made, establishing a 10-degree noseup attitude at about 10 feet above the ground and using the collective pitch to cushion the touchdown. If a shorter landing distance is required, a moderate flare should be performed above 25 feet to decelerate the helicopter, then establish a landing attitude and cushion the touchdown with the collective pitch. The first technique provides better control of the touchdown force, but consumes more distance. The second method requires a shorter distance, but may result in a hard landing if too much airspeed and/or rotor rpm is lost too high above the ground.

CONCLUSIONS AND RECOMMENDATIONS

The results of the single-engine height-velocity tests obtained from this evaluation verified the height-velocity characteristics previously established by the contractor.

The results of these tests apply only at low altitudes (approximately 5,000 feet and below).

1. Further tests should be performed to define the single-engine height-velocity characteristics at altitude (page 4).

The Flight Manual contains no discussion on techniques to be followed for an engine failure near the AVOID area of the height-velocity curve.

2. The discussion on page 4 of this report should be included in the Flight Manual.

REFERENCES

1. Barbini, Wayne J., Balfe, Paul J., Major USAF, Lovrien, Clark E. Jr., Major USAF, Category II Performance and Flying Qualities Tests of the HH-53C Helicopter, FTC-TR-70-8, Air Force Flight Test Center, Edwards AFB, California, April 1970.

2. Military Specification, Helicopter Flying and Ground Handling Qualities; General Requirements for, MIL-H-8501A, 3 April 1962.

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